Installing Towers Safely

Paying to have a tower installed can be very expensive. Installing it incorrectly can be far more expensive. Here are some guidelines to ease the cost and ensure safety.

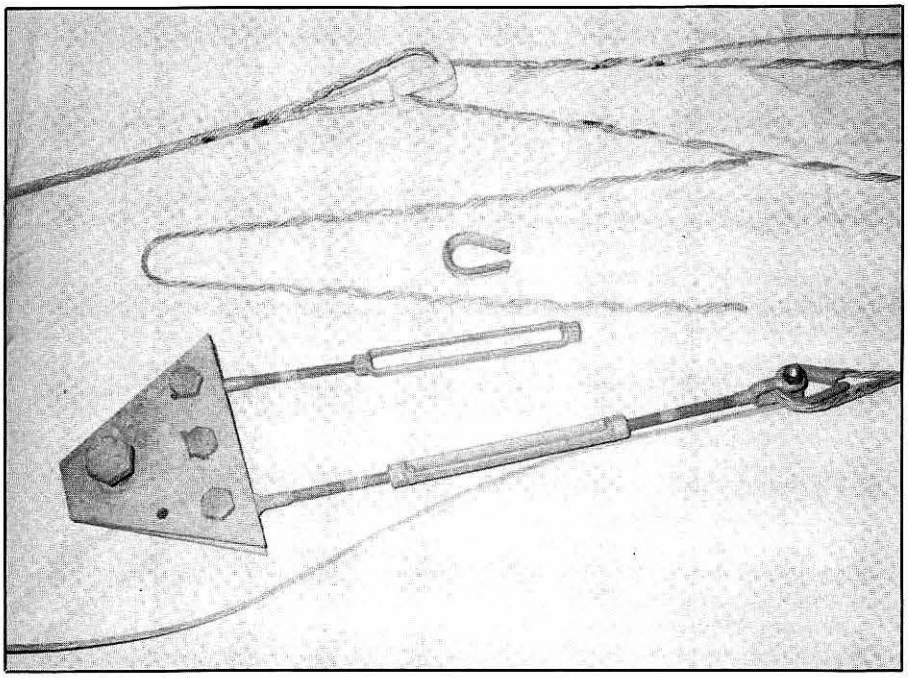
BY PETER O'DELL, WB2D

If you think that you can slap together a tower in a couple of hours and have nothing to worry about, consider what happened to a friend recently. He'd just spent over $2000 on the materials, all first class, for his 120-foot tower that was to be the cornerstone of a serious contest station. My friend is not inexperienced. He's had several competitive contest stations up and running in the different areas that he's lived in.

At the last minute during the installation, he discovered that he was missing an eyebolt for the guy anchors. Rather than wait a few days for a shipment to come in from a major tower-hardware dealer, my friend went down to the local hardware store and picked up one of their eyebolts. He completed the installation in time for the CQ WW in October.

Three days after the contest, the winds came up strong, as they often do where he lives. The eyebolt, which was an import of questionable quality, snapped off letting the three guy wires go. When the dust settled, $2000 worth of tower was a crumpled mass of scrap metal. The only good things were that no one was hurt and the tower did not damage my friend's home (he has several acres).

So you see, towers are no joking matter. But that doesn't mean that the only safe way to install a tower is to hire a professional rigging company to do the work for you. If you follow the manufacturer's instructions, get some friends to help and use some common sense, you should be able to do a good job.



A selection of guy wire accessories. Top to bottom: An insulator with one completed guy grip and a second just started; a guy grip with a thimble nested inside; and an equalizer plate with turnbuckles attached.

How Do Towers Work?

"Well, they hold the antenna up in the air, right?" It's not so simple as it might seem. You must think in terms of *how* they hold the tower up. There are essentially two principal types of towers—those with guy wires and those without. Of course, within each type there can be major variations. For instance, self-supporting towers (those without guy wires) either may be designed with stacked sections for a fixed height or with nesting sections for a "crank up" tower.

Guyed and self-supporting towers function differently in spite of the fact that you cannot see the forces that act upon them. Because of that, things that are appropriate for one differ from things that are appropriate for the other. Things that you can "get away with" for one become fatal flaws in the other.

Consider the effect of wind on a tower and antenna system. Look through the antenna chart section elsewhere in this *Buyer's Guide* and you will find a column heading called "square feet." Facing the wind, an antenna has height and width—admittedly the height may not be great, but it is there nonetheless. All those elements and the boom have width, lots of it for some of the larger arrays. All those "widths" and height together mean area, and that area adds up. Putting an antenna with 10-square-feet area on your tower is the same thing as putting a sail with the same square footage up there. Sails

can be used to move huge ships across the oceans, even in very moderate winds.

Self-Supporting Towers

What keeps the tower from sailing away in the wind? Lets consider a self-supporting tower first (Fig. 1). As the wind blows, the tower begins to sway—it's designed to do that. The wind moves the top of the tower in the same direction that it is blowing in. That flexing pushes down the side of the tower opposite the direction that the wind is *coming from.* At the same time, the opposite side of the tower (the one facing the wind) is being "pulled up."

Obviously, the only thing that holds the tower in place is the base. What's happening at the base? It is as if a huge lever (such as a torque wrench) has been attached to the base and is trying to rotate it. A great deal of the wind-generated energy will be dissipated as heat at the base. But recall that the self-supporting tower is designed to flex. Some of the energy is simply "stored" in the resilient tower sections. As the wind momentarily dies or switches direction, the energy is used to flex the tower back in the other direction.

When I worked for a two-way radio shop, I occasionally had to climb self-supporting towers. On one occasion, I was near the top of a 150-footer. It was a warm summer day with no breeze that I could detect. The slightest movement on my part would cause the top section to sway several feet. Since I was busy working and wanting to get down as quickly as possible, I wasn't paying much attention to it. My co-worker, who was acting as my "ground crew," finally yelled up to me that he was going to sit in the truck. He said he was getting seasick just watching me. Self-supporting towers are meant to sway.

The first tower that I ever owned was a self-supporter. When it came time to install it, another friend came by to help me. He looked at the bags of premixed concrete that I had stacked up at the site and told me that I was crazy. As far as he was concerned, I was going way overboard in the amount of concrete that I was putting in the base. He felt that maybe one-fourth the amount that I was using would be enough. In spite of his complaining we used all the concrete that I had purchased, and I'm glad that we did. But from a certain perspective, my friend was not wrong. Why?

Guyed Towers

My friend had never worked with a self-supporting tower before. All his experience was with the guyed variety. How is the guyed tower different? When the wind blows against a guyed tower, the tower does not flex (Fig. 2). That is because the manufacturer has specified a certain amount of tension on each guy wire for proper installation. You may wonder what happens to the energy transferred to the tower by the force of the wind.

Perhaps it's a little more difficult to grasp intuitively, but the wind is converted into a downward push on the tower. That push is as strong on the side facing the wind as it is on the side opposite the wind. Therefore there is no "uplift" generated; nor is there a turning moment generated on the base. The tower is simply being pushed into the ground.

What does that mean with respect to the tower base? Imagine a woman in spiked high heels standing next to someone in sneakers in a garden just after a rain storm. Those spikes are going to sink rapidly into the ground, but chances are the sneakers won't. To carry the analogy over, the base must be strong enough to resist the downward pressure; so it must have some area to spread the force out over. But *if the soil is tightly compressed,* the base can consist of substantially less concrete than what would be required for a self-supporting tower of the same size. In practical terms, what that means is that you really need to dig below the topsoil and pour a base that may be only a few inches larger than the outside dimensions of the bottom section of the tower.

This becomes tricky when dealing with some soil variations, such as sand or a marsh. In such cases, a larger base will be called for. Most tower manufacturers specify the size of the base that is necessary for their product. Their directions may call for increasing the size of the base when using more tower sections or for particular types of soil. A reputable manufacturer will conservatively engineer his tower and base specifications. It is risky, to say the least, to cut any corners on the base, and it is always best to follow the manufacturer's specifications exactly.

Another point to keep in mind about guyed towers is that you must pay attention to the guy spacing up and down the tower. Why? Let's take an extreme example. Suppose that you have a 100-foot tower with only one set of guy wires at the top. As the winds come up, the tower is being pushed down. Where is the weakest point? Well, the top is held in place by the guy wires, and the base is held in place by the earth. Intuitively, it would seem that the weakest point is half way between the two, and that is correct. A strong wind may cause such a hard downward push that the center buckles. In fact, this is how many guyed towers do

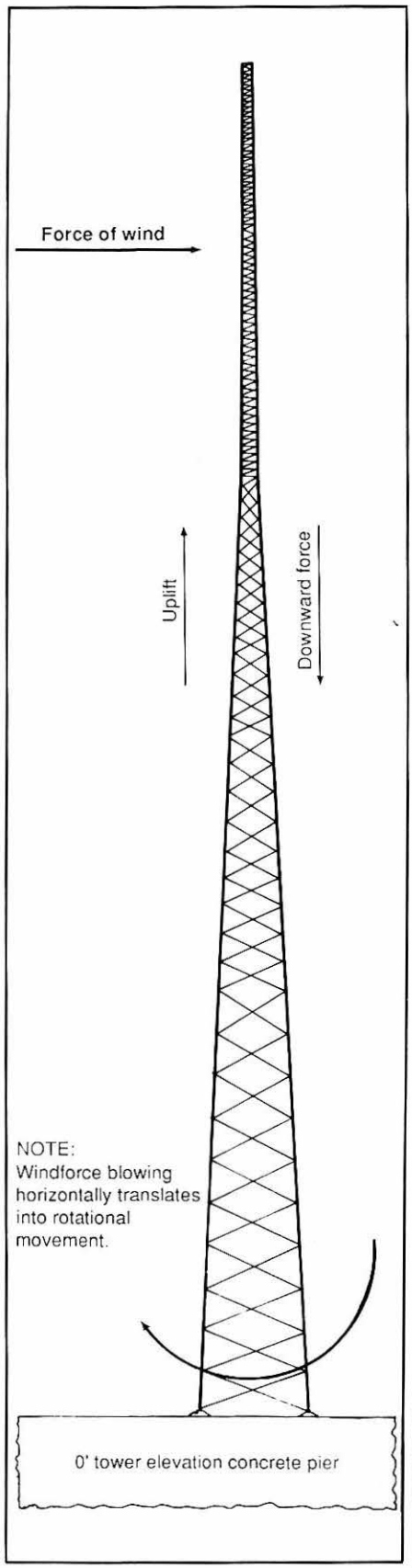


Fig. 1– Self-supporting tower. The force of the wind causes this tower to develop a turning moment at the base. The base must be fashioned so as to resist these forces.

fail. One of the mid-range guys fails, permitting the tower to buckle at that point. Guyed towers seldom fall over straight out from the base. The debris often bears some resemblance to an accordion. In short, guyed towers should not flex.

Around And Around

Another force that acts on both varieties of towers is that of torque generated by rotating an antenna (Fig. 3). If the area of the antenna is not symmetrical with respect to the boom-to-mast bracket, torque will also be generated each time the wind blows. (See "A Primer On Antenna Rotator Selection" elsewhere in this *Guide*.)

When an antenna is started to rotate, torque is developed in the direction opposite of the rotation. In other words, in free space with the tower and antenna attached to nothing but each other, the tower would rotate in a direction opposite to that of the antenna when the rotator was turned on. In the real world, the tower is attached to something—the ground. The tower attempts to rotate. Again, it is the base that stops it from rotating.

Crank-up Towers

One common tower type is the crank-up (Fig.4). In a standard fixed-height tower, the bottom of the second section is bolted to the top of the first section; this pattern is repeated up through the height of the tower to the top section. In the crank-up variety, the sections are not bolted together at all. When the tower is retracted, the sections all nest one within the other. A system of pulleys and steel cable cause the tower to telescope upwards when the cable is taken up on the winch spool.

Fully extended, the crank-up tower bears a strong likeness to the ordinary free-standing variety. As a rule, crank-up towers are not as strong as their fixed-height cousins. The manufacturers expect the tower to be retracted or nested during periods of inclement weather.

There are several mistakes that amateurs often make where crank-up towers are concerned. Potentially the most dangerous mistake is to climb the tower and perform work on it when it is extended. The only thing that is holding the sections up in the air is the cable that runs from pulley to pulley. Cables break. Suppose you were standing on one of the rungs of the top section when the cable snapped. What would happen to you? It's not a pretty picture. If you lived, it is most likely that you would be crippled for life.

Now, suppose that you were standing on one of the rungs near the bottom. What would happen? Because the sections nest, it is most likely that you would lose a few fingers and toes at the least. It only takes a few minutes to crank the tower down to its nested position. That's the first step you should take before doing anything else with a crank-up tower.

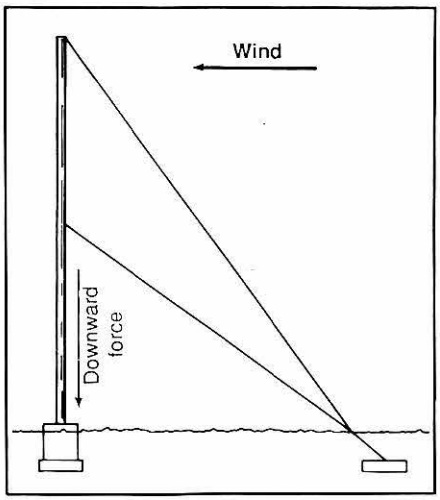


Fig. 2– A guyed tower and the forces operating on it. Because of the tension on the symmetrically placed guy wires, no up lift develops and the tower does not flex. The result is that the entire force of the wind is translated into a downward thrust that the base must support.

You may be thinking that such things are certainly possible, but that they couldn't happen to you. Jerry Hall, K1TD, tells a story about a crank-up tower that he owned several years ago. It was new, so he assumed that nothing could possibly go wrong. It was fully extended to its 70-foot height, and he just needed to make a minor adjustment to an antenna that he was experimenting with. Cranking it down seemed like such a lot of work, not to mention cranking it back up again. After climbing to the top and making his adjustments, he came down the tower. Just as he stepped off the bottom and turned to walk back to the shack, he heard a snapping sound, a "whoosh" and a crash. In the next instant he was standing in a forest of aluminum tubing sticking up out of the ground.

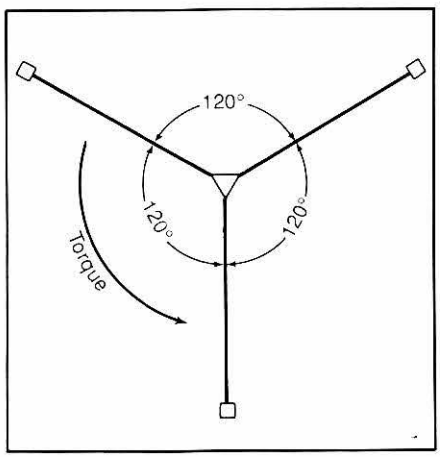


Fig. 3– Overhead view of a guyed tower. The three sets of guy wires are positioned symmetrically. Rotating the antenna develops a torque that would tend to "cork screw" the tower.

Some of the element tubing was imbedded more than a foot in the soil. Jerry was extremely lucky. If you own a crank-up tower and insist on climbing it in its extended position, before you take that first step follow Clint Eastwood's advice and ask yourself "Do I feel lucky today?"

A second mistake that hams sometimes make with crank-up towers is not quite so obviously dangerous. In fact, it might seem like a step taken to make the tower safer. It isn't, though. Some hams will look at a crank-up tower swaying in the wind and fear that the tower will be damaged. If the wind is blowing strong enough to damage the tower, it should be retracted to its fully nested position. Someone may get the idea to make it stronger by adding guy wires. Wrong!

Recall how the guyed tower works. The force of the wind is converted to a downward pressure that causes the tower to push down on the base. That pressure is transferred from one section to the next. With one section setting on top of the other, the force is transferred down through each section. What happens when the sections aren't bolted together but are supported by the cable and pulleys? The cable and pulleys are the two parts of the tower that are subjected to the force. And it may be a force greater than what they can cope with. In short, adding guy wires to a crank-up tower is an invitation to disaster.

Crank-up towers are often praised for their safety because the antennas are closer to the ground when the tower is completely retracted. There is a certain logic to this, but I just don't buy it. I would never climb any kind of a tower without a climbing belt. After I coaxed myself up those towers the first few times and whipped my fear of heights, I learned to trust that belt completely. Somehow, standing on top of a 16-foot step ladder to fiddle with an antenna just doesn't seem all that safe to me. What can you attach the belt to?

Don't fool yourself about how high you have to be to seriously injure yourself if you fall. I have another friend who didn't bother to use his climbing belt because he was only going to the 12-foot level of the tower to tighten a bolt. He slipped and broke his back in the fall. These days, he can walk, but he will never climb another tower.

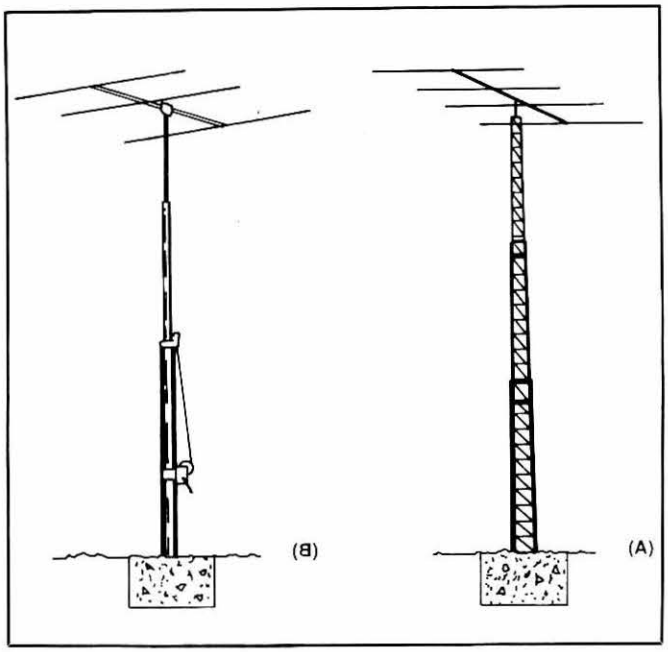


Fig. 4– Two varieties of crank-up towers.

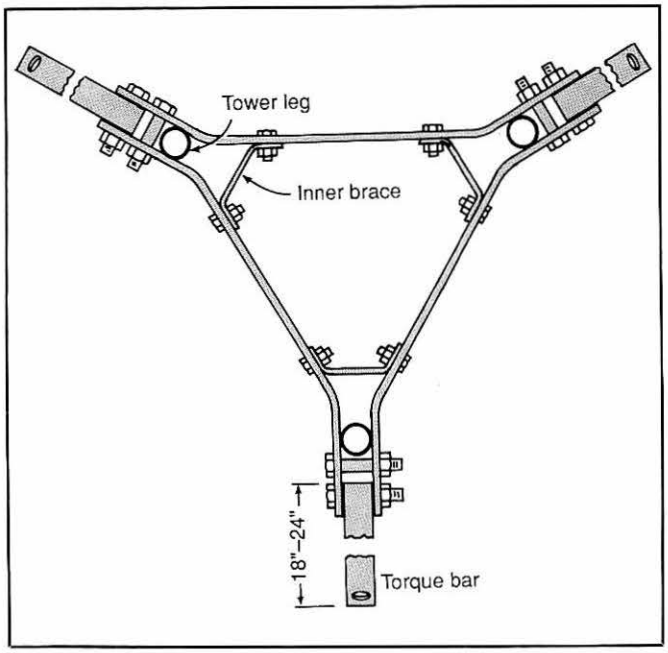


Fig. 5– A torque bracket. Because the torque bars are rigid, they tend to increase the effective radius of the tower, which minimizes the effect of torque.

Another feature designed to bring the antenna close to the ground for servicing is the tilt-over section or base. What it amounts to is a large hinge that allows all or a portion of the tower to tilt over. It makes the tower more complicated, which to me means weaker. Unless things are perfectly balanced, there's always the chance that it will get away from you while tilting it up or down. It's just one more thing where something can go wrong.

Specialty Towers

In an article of this size and scope it is impossible to cover all the types of towers that are available for amateur use. For instance, Curt Fouse, K8UC, purchased an abandoned oil derrick and over a period of about a year erected it in his backyard—he lives on a farm and did not have to contend with a zoning board! He's also an expert welder and has a good working knowledge of what metal can and cannot be expected to do.

Another variety of tower that requires special expertise is the rotating tower. Here the whole tower, or at least a major portion of it, is designed to rotate along with the antennas attached to it. Usually this is done to enable the use of stacked antennas that must have a substantial vertical separation to perform properly. The major market for commercial versions of these towers is the military, and they carry the expected price tag. If you are not a first-class mechanical engineer, you would be ill-advised to attempt to fabricate such a tower without expert assistance.

Still another variety of tower is the "roof tower." Within this classification, there is an almost endless variety of possibilities. They range from simple tubular tripods to special bases that permit mounting regular tower sections on a roof. Unless you are erecting very small antennas, a great deal of investigation, planning and care should go into erecting such a tower. Most roof towers require guying. That means that the wind effects are going to be translated into a downward thrust to the roof.

If your house has a shingle roof and has been reroofed, chances are that the second layer was simply placed on top of the first layer. Most engineers say that this is okay, but a third layer's weight would likely be excessive and, therefore, should not be added. Suppose that you add the roof tower to a roof with two layers of shingles. In the dead of winter, you get a major storm that dumps 18 inches of heavy snow on your roof. Now assume your roof tower supports a large tribander that develops a lot of ice loading during the storm. Not only is the ice heavy, but it dramatically increases the surface area (square footage of the antenna). Winter storms are often accompanied by strong winds. The combination may be too much for your roof. Consequently, if you are planning a roof tower and have any doubts, it would be advisable to contact a competent engineer for advice.

Assuming HF operation is anticipated, there is a second consideration for roof towers. You will be bringing the antenna closer to the wiring within the house. This means that you will be increasing the likelihood of coupling your transmitted signal into the wiring. This, of course, increases the likelihood of experiencing interference in other electronic devices.

Guyed Tower Accessories

There are a number of accessories that can make life with a guyed tower a lot simpler and safer. Assuming that you are using standard metallic guy wire (3/16 or 1/4 inch EHS), you will need to use insulators to break the guy wire up into nonresonant lengths. Basically, there are two methods for attaching the guy wire to insulators, towers and guy anchors. The traditional method calls for passing the wire through, say, the insulator. Three or four clamps are used to secure the guy wire to itself after it has been folded back on itself. Finally, the free end of the stranded cable is unraveled. A "serving tool" is used to wrap individual strands of wire around the guy wire until all the strands are wrapped around in this fashion. At best, it is a time-consuming endeavor.

A second procedure uses preformed cable grips. These U-shaped devices are specially made so that each end wraps around the cable in alternating layers. The preformed grip passes through the insulator, tower leg or whatever. An ex-

perienced user can install a preformed grip in under five minutes. They are reusable, too. Best of all, when properly installed they are every bit as secure as serving the end of the cable.

Whether you opt for preformed guy grips or for serving the cable ends, you will need to use thimbles where the cable or grip passes through anything other than an insulator or tower leg (e.g., torque bars, eyebolts, turn buckles, etc.). A thimble is simply a small, grooved, U-shaped piece of metal. The thimble is passed through the opening in the, say, torque arm. Then the cable or preformed grip is passed through so that it fits inside the groove of the thimble. The thimble protects the cable or grip from damage caused by sharp edges and bends.

Manufacturers specify the tension that should be placed on each guy wire. Too much tension on the guy wires on one side of the tower could have disastrous consequences. There are two devices that make balancing the tension much easier. First, there is the ordinary turnbuckle—ordinary, but also *high quality* to avoid disaster. Twist the turnbuckle one way for increased tension and the other for decreased. It is as simple as that. Once the proper position is found, pass a short length of guy wire through the turnbuckle and anchor it so that the turnbuckle cannot twist on its own.

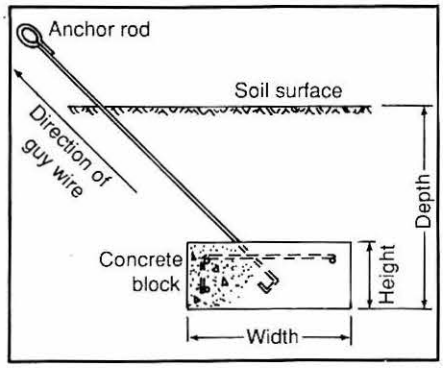


Fig. 6– A concrete anchor. The anchor rod has a hooked end, which keeps it firmly imbedded in the concrete block. The concrete block is reinforced with rebar.

A second device that can be used to balance the tension in guy wires is the equalizer plate. The equalizer plate provides a convenient means for attaching several guy wires to one anchor. It is made so that it will shift position slightly, tending to keep the tension equal at all levels of the tower.

If you will be installing large arrays on a guyed tower, it is wise to use torque brackets to affix the guy wires to the tower (Fig. 5). A torque bracket provides a rigid extension arm that sticks out from the tower and to which the guy wire attaches. This has the effect of increasing the diameter of the tower with respect to torque. In other words, it tends to prevent twisting of the tower when the antennas are rotating or stopping.

Finally, if you are installing a guyed tower, you will have to decide what sort of guy anchors to use. In some cases it may be decided for you by the building authorities. Across all soil types, the safest guy anchor consists of an anchor rod imbedded in a concrete block buried a few feet below ground level (Fig. 6). Obviously, such an anchor requires digging and preparing the hole. It also requires concrete, which adds to the cost.

A less expensive means is to use earth screws. It is similar to the anchor rod except that a large screw-type blade is affixed to the end opposite the end where the guy wires attach. The earth screw is positioned such that its shaft lines up with the direction of the guy wires. The installer then uses a large lever to screw the rod into the ground to a depth of 3 to 4 feet or more.

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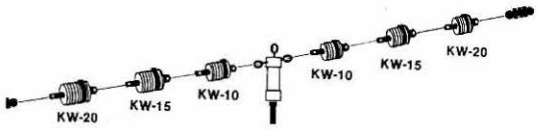

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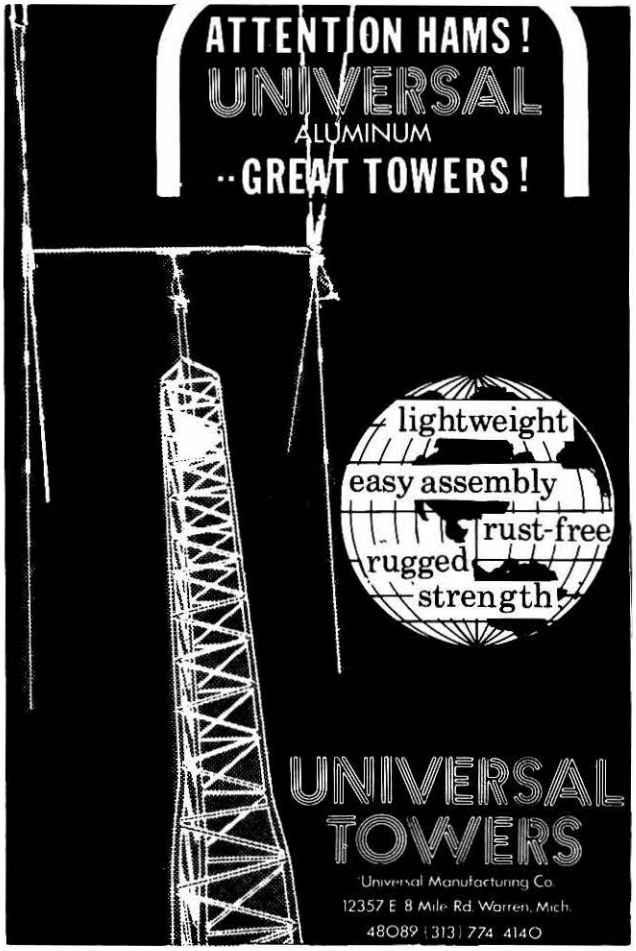

screws should be secure enough for most moderate sized amateur towers. However, earth screws should not be used in sandy or marshy soil. Additionally, larger rocks or tree roots may prevent proper installation. For these reasons, most manufacturers (and town building codes) usually specify the concrete-type anchors.

Recommendations

There is an endless variety of possibilities for what sort of tower to install. Let's assume that you are about to install your first tower. You live in a suburban area that will permit a reasonable height, perhaps 70 feet, and you have enough land to make this feasible. You plan to use a large tribander (six or seven elements).

Looking over the price charts, you find that the guyed tower sections necessary to make up 60 to 70 ft come in at a few hundred dollars less than a self-supporting tower of that height—and substantially less than a crank-up. The economical choice would appear to be the guyed tower. But add in the cost of the guy wire, torque brackets (you'll need two), insulators, preformed grips and all the other odds and ends. Now there isn't too much difference in the cost.

Having guy wires in your back yard is a nuisance at best. Sally (my wife, WB2E) says that they are eyesores, and most of the neighbors seem to agree. It is difficult to run the lawn mower around them. There is much to be said to avoiding them.

Since you can easily obtain the permit to install the tower, there is little that would be gained by having a crank-up. (Yes, I know that having a crank-up means that you can work on the antennas much closer to the ground. I just don't think that the added cost and dangers associated with the crank-up are worth it if it is not legally necessary.) So, for this circumstance, I would recommend going with a fixed-height self-supporting tower.

If you plan on going higher, having more antennas (e.g., Christmas tree style monobanders) or you just think that you might want to someday, then you will be better off to go with a guyed tower. You can start small and add sections as money becomes available. Guyed towers will support more antennas safely, too.

Now, suppose that you are limited to some height under 40 feet. Here's where the crank-up tower comes into its own. For a beam antenna to work properly, it should be at least 50 feet above ground, as a rule of thumb. In some communities, the only way that you will get that is with a crank-up tower.

If you plan a tower between 40 and 60 feet, I would probably go with a self-supporting tower for all the reasons mentioned above. With the antenna at that height, it is unlikely that you will be a big gun. Chances are that a tribander will serve you well.

If you are thinking about a tower, do your home work. You'll want to read the other articles in this *Buyer's Guide*, particularly those by Messrs. Clift, Cain and Gentry. You should also get a copy of ARRL's *Antenna Book* and read the chapters on towers and safety in it. Once you've narrowed the choice down, obtain literature from all the manufacturers who have products that interest you. Visit the stations of hams in your areas who have installations similar to what you plan. Look them over carefully; you're sure to find useful ideas. Plan ahead, work slowly and safely. You will have an antenna farm that works well, and it will last.

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TX-472	72'	22'8"	4	1040	12½"	21⅝"	$2529.00
TX-472MDP*	72'	22'8"	4	1210	12½"	21⅝"	$4069.00
TX-489	89'	23'4"	5	1590	12½"	25⅝"	$4399.00
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Will handle 30 sq. ft. antennas at 50 MPH winds.

MODEL NO.	HEIGHT MAX.	HEIGHT MIN.	NUMBER SECTIONS	WEIGHT POUNDS	SEC. OD Top	SEC. OD Bot.	SUGGESTED HAM PRICE
HDX-538	38'	21'6"	2	600	15"	18"	$1319.00
HDX-555	55'	22'	3	870	15"	21⅝"	$2309.00
HDX-572	72'	22'8"	4	1420	15"	25⅝"	$3959.00
HDX-572MDPL*	72'	22'8"	4	1600	15"	25⅝"	$6049.00
HDX-589MDPL*	89'	23'8"	5	2440	15"	30⅝"	$7919.00

*Includes heavy-duty motor drives with dual level wind and positive pull down. HDX-572MDPL includes limit switch brackets only. HDX-589MDPL includes limit switches and limit switch brackets.

FREE STANDING "LOW PROFILE" COMPACT CRANK-UP TOWERS.
Will handle 18 sq. ft. antennas at 50 MPH winds. (TMM-433HD handles 24 sq. ft.)

MODEL NO.	HEIGHT MAX.	HEIGHT MIN.	NUMBER SECTIONS	WEIGHT POUNDS	SEC. OD Top	SEC. OD Bot.	SUGGESTED HAM PRICE
TMM-433SS*	33'	11'4"	4	315	10"	18"	$1089.00
TMM-433HD*	33'	11'4"	4	400	12½"	20⅞"	$1319.00
TMM-541SS*	41'	12'	5	430	10"	20⅞"	$1429.00

*Hy-Gain and some Alliance rotors when installed inside tower will restrict retracted height by approx. 24". Most Kenpro models allow full retraction.

Shown w/optional MARB550 rotorbase and rotator.

Tower ratings to EIA specifications
Standard bases included with all towers (except MA-770, 770-MDP and 850-MDP).

Full line of Accessories including:
• Tower motor drives • 5' to 24' antenna masts • Coax arms
• Thrust bearings • Mast raising fixtures • Rotating bases
• Limit Switch Packages

CALL FOR FREE CATALOG

FOR ADDITIONAL INFORMATION CONTACT:
Amateur Electronic Supply (All locations) • Texas Towers
Ham Radio Outlet (All locations) • U.S. Tower (209) 733-2438
Prices are FOB, factory: Visalia, CA. Prices and specifications are subject to change without notice.